FINAL REPORT

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"ASSESSMENT AND QUANTIFICATION OF CUMULATIVE IMPACTS OF TRAINING AND LAND MANAGEMENT PRACTICES ON MILITARY INSTALLATIONS"

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ABSTRACT

Military vehicle maneuvers remove vegetation and increase the potential for soil erosion. Quantifying the vegetation removed during military maneuvers is needed to assist land managers in maintaining the environmental integrity of the training area. A terrain-vehicle impact model was used to predict terrain impacts (disturbed width and impact severity), based on vehicle properties, operating characteristics and soil strength properties. The cumulative impact width (CIW), a product of the disturbed width and impact severity, is the width of vegetation removed resulting from a passing wheeled or tracked vehicle. The vegetation removed is a direct indicator of increased soil erosion from the training area.

By tracking military vehicles during maneuvers, the vehicle movement pattern and the resulting vegetation removed can be determined. The approach was used to determine the vegetation removed during an eight-wheeled Stryker military maneuver at Pohakuloa Training Area in Hawaii. A Stryker reconnaissance platoon (3 vehicles) of the 2nd Brigade of the 25th Infantry Davison was tracked during an off-road proofing mission on the Keamuku parcel using GPS-based tracking systems to determine vehicle movement patterns and estimate soil loss impacts. Total vegetation removed was estimated from the vehicle operating characteristics (velocity and turning radius) determined from the GPS data. An average of 1,251 square meters of vegetation removed per vehicle during the proofing maneuver was estimated. An average of 9.1 km of off-road travel distance was measured per vehicle, with an average speed of 3.69 m/s. Off-road travel accounted for less than 10 percent of the total distance travelled.

Spiral impacts were conducted to evaluate the influence of vehicle velocity and turning radius on terrain impact. Sharper turns and higher speeds produced more vegetation removed. A vegetative recovery study was conducted indicating over 90 percent of the vegetation returned in the following the 15 month period.

Introduction

The Stryker Brigade Combat Team Final Environmental Impact Statement, Hawaii (SBCT EIS, Hawaii) identifies several areas of "significant impacts" related to the Stryker Transformation. The first item listed is "Soil loss from training activities. Increased soil erosion may result from mounted and unmounted maneuver training, …". Analysis in the SBCT EIS, Hawaii indicates the transformation "would result in degradation of land condition to a "severe" condition on average." Soil loss results from dust emissions and soil erosion. Both are accelerated by the vehicle impacts resulting from maneuver training. By understanding the vehicle movement patterns and soil impacts during maneuvers of the 2nd Brigade of the 25th Infantry Division, projections of site-specific soil impacts and mitigation strategies can be developed.

Objective

The purpose of this project is to conduct vehicle tracking studies and analyze vehicle movement patterns of a proofing maneuver conducted by 8-wheel Strykers of the 2nd Brigade of the 25th Infantry Division. The results of this study will be used to assist in meeting the soil loss monitoring and mitigation requirements stated in the SBCT EIS, Hawaii.

Approach

Previous vehicle tracking studies have been successfully conducted at Yakima Training Center (2002), Fort Lewis (2005), and Fort Riley (2005) (Haugen et al., 2003; Ayers et al., 2007). In these studies, self-contained GPS-based vehicle tracking system (VTS) boxes are mounted on the selected vehicles just prior to initiating maneuvers. The VTS developed for vehicle tracking consists of a WAAS differential Global Positioning System (DGPS) receiver, a serial data recorder, a data storage card, batteries(s), and a waterproof case. The system was developed to be lightweight, mobile, and flexible. It is a completely self-contained system requiring no electrical connection to the vehicle power supply and can collect 8 days of GPS positional data depending on the configuration.

The Garmin GPS18-PC GPS receiver was selected for the vehicle tracking system because it is lightweight (3.9 oz), small in size (1.05"x3.79"x2.22"), can be attached to the vehicle with a magnet, has a wide range of operating temperature (-30°C to 85°C), and a wide range of input voltage (6 VDC to 40VDC unregulated). The Garmin GPS18 GPS receiver has one cable through which the power is supplied to the receiver, GPS data is output to the storage card on serial data recorder. The Garmin GPS18 can track up to twelve satellites at an update rate of one second and provides WAAS differential correction. The Garmin 18 has a magnetic mount that can be placed on the VTS box, vehicle or a metal plate attached to the vehicle.

The Acumen Serial Data Recorder (SDR) is used for the vehicle tracking systems. A Compact Flash card is used for data storage in the vehicle tracking system. The SDR's operates on 8 to 15 volt DC power.

A 12-volt direct current power supply is used in the vehicle tracking system because the Garmin GPS18 and SDR operate with 12 VDC power. The Odyssey

rechargeable Drycell 12 volt battery (P/N PC625) was selected for the vehicle tracking system because the battery can provide 12 volts for 17 amp-hours, which corresponds to approximately 96 hours of power to the Garmin GPS18-PC and SDR. The Odyssey rechargeable Drycell 12Vdc battery is of starved electrolyte dry cell electrochemical design and can be air-freighted. Simple 12 volt automotive plugs are used to attach the battery to the Garmin GPS18 and SDR.

A Kinetics dry case (P/N KC613E) is used to house the vehicle tracking system equipment. A hole was drilled in the side of the case for the Garmin GPS18 cable, the case is watertight, shock proof, has a wide temperature range. The size of the case (14" x 10.6" x 6.1" outside, 13.4" x 8.9" x 5.6" inside) fits the SDR, two batteries, all wires connections, and the power accessories. The case weighs approximately 30 lbs with two batteries and all equipment.

The VTS has the capability to collect location data every second over an 8-day training period. GPS data is stored on a compact flash storage card. The VTS is removed from the vehicle following the maneuvers and the GPS data is collected from the storage card. The GPS data describing the vehicle tracking can be analyzed to determine:

- distance traveled by each vehicle
- off-road and on-road traffic
- vehicle off-road velocity and turning characteristics
- location and degree of vegetation/soil loss impacts

For the tracking data, disturbed width and impacts severity were determined using theoretical models generated by Li et al. (2007). Soil cohesion and friction angle were measured on-site with a Cohron torsional sheargraph.

To evaluate the influence of speed and turning radius on vegetative impacts, the Stryker conducted spirals at 3 speeds, low, medium and high. A total of 8 spirals were conducted (3 low, 3 medium and 2 high speeds). The vehicle was initially driven straight, then proceeded to turn with a continuously deceasing turning radius. At approximately 15 points along each spiral the disturbed width and impact severity was determined. The cumulative impact width (CIW) was calculated as the product of the disturbed width times the impact severity, and was matched to the vehicle turning radius.

Results

The results of the spiral study are shown in Figure 1. Higher speeds and lower turning radii tended to produce higher vegetative impacts. Relationships between the vegetation removed (cumulative impact widths) and the vehicle operating conditions (velocity and turning radius) were determined.

Vehicle tracking was conducted during the one-day Stryker proofing study (Figure 2). Figure 3 shows the vehicle tracks for the 3 Strykers during the proofing maneuver. Table 1 summarizes the vehicle movement patterns for the 3 Strykers during the proofing maneuvers. Most of the movement was on-road (over 90%). For the off-road travel, an average of 9.1 km of off-road travel distance was measured, with an average speed of 3.69 m/s. For the 3 vehicles, an average of 1,251 meter square of vegetation removed per vehicle during the proofing maneuver was estimated. Figure 4

shows the amount and location of the vegetation removed during the Stryker proofing mission.

An analysis of vehicle movement showed the travel was in the lower elevations of the area. Figure 5 show the vehicle tracks as related to the training area topography. Mostly the valleys and plateaus are traversed, as the vehicles stayed off the steep slopes where possible.

Vegetative recovery is important in understanding the sustainability of training maneuvers at an installation. The Stryker spirals were reevaluated one month and 13 months after the initial impacts (Figure 6). Substantial vegetative recovery (regrowth) occurred after the first month. Over 90% of the vegetation had recovered after 15 months of the initial impact.

Conclusion

A study was conducted to determine the vegetation removed during an eight-wheeled Stryker military maneuver at Pohakuloa Training Area in Hawaii. A Stryker reconnaissance platoon (3 vehicles) of the 2nd Brigade of the 25th ID(L) was tracked during an off-road proofing mission on the Keamuku parcel using GPS-based tracking systems to determine vehicle movement patterns and estimate soil loss impacts. An average of 1,251 meter square of vegetation removed per vehicle during the proofing maneuver was estimated. For each vehicle, an average of 9.1 km of off-road travel distance was measured, with an average speed of 3.69 m/s. Off-road travel accounted for about 10 percent of the total distance travelled.

Spiral impacts were conducted to evaluate the influence of vehicle velocity and turning radius on terrain impact. Sharper turns and higher speeds produced more vegetation removed. A vegetative recovery study was conducted indicating over 90 percent of the vegetation returned in the first 15 months after the initial impact.

Acknowledgements

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References

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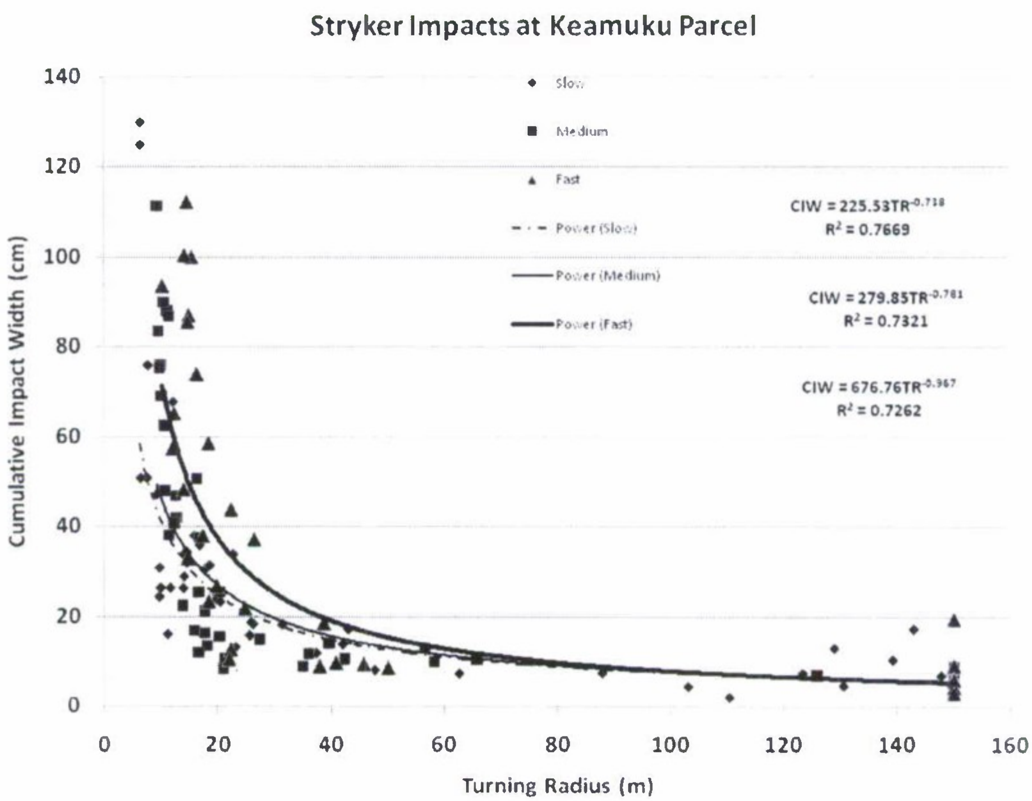

Figure 1. Stryker impacts resulting from spiral maneuvers.

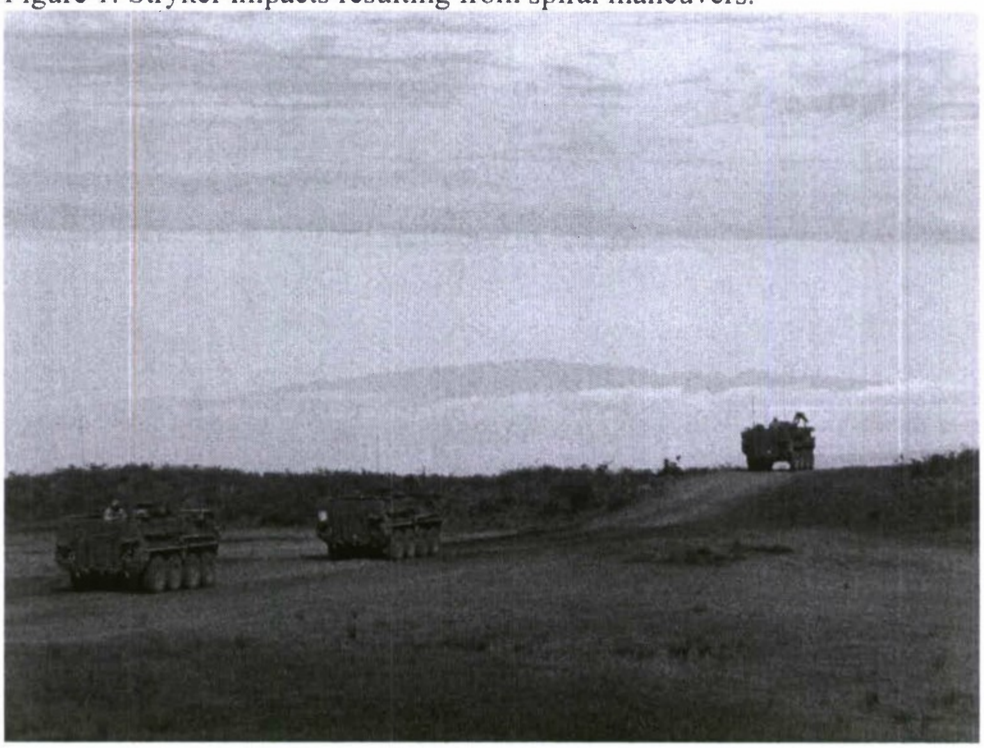

Figure 2. Stryker vehicles conducting proofing study.

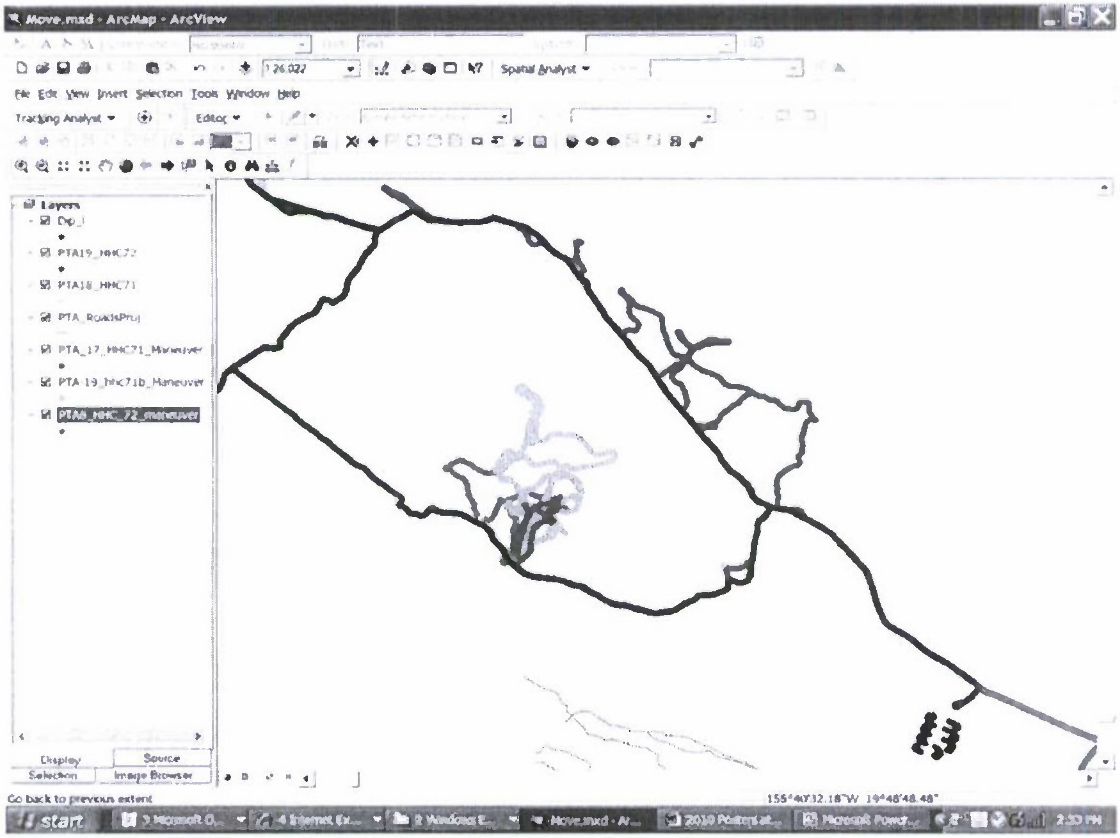

Figure 3. Vehicle track during Stryker proofing maneuver.

Table 1. Stryker vehicle movement patterns during proofing maneuver.

	Total		On-Road		Off-Road		Vegetation Removed
Vehicle	Distance (km)	Avg. Speed (m/s)	Distance (km)	Avg. Speed (m/s)	Distance (km)	Avg. Speed (m/s)	Area (sq m)
PTA 08	65.27	4.86	59.37	5.09	5.90	3.33	722
PTA 17	118.30	5.00	106.45	5.17	11.85	4.00	1642
PTA 19	117.32	5.15	107.67	5.33	9.65	3.75	1388

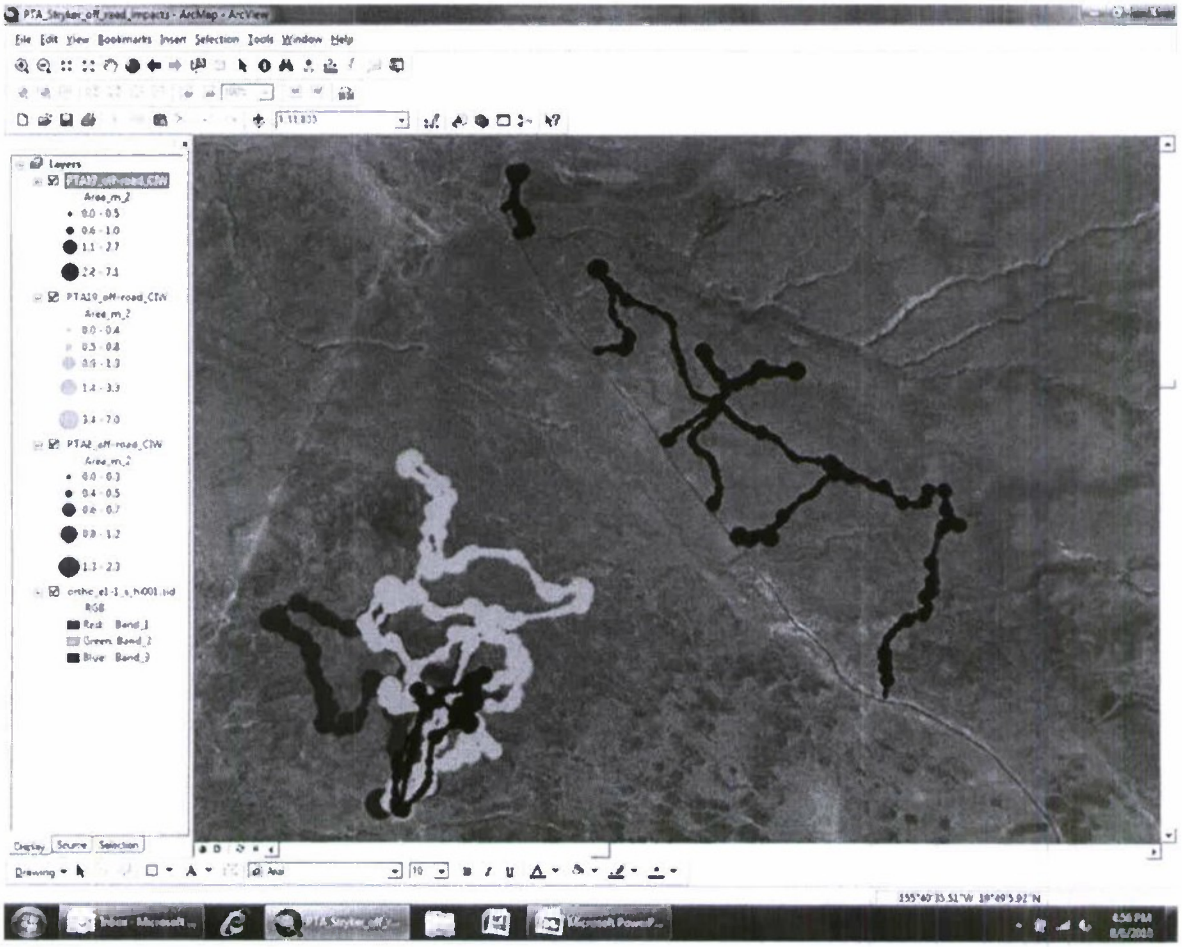

Figure 4. Cumulative impact width (vegetation removed) for the off-road portion of the Stryker proofing maneuver.

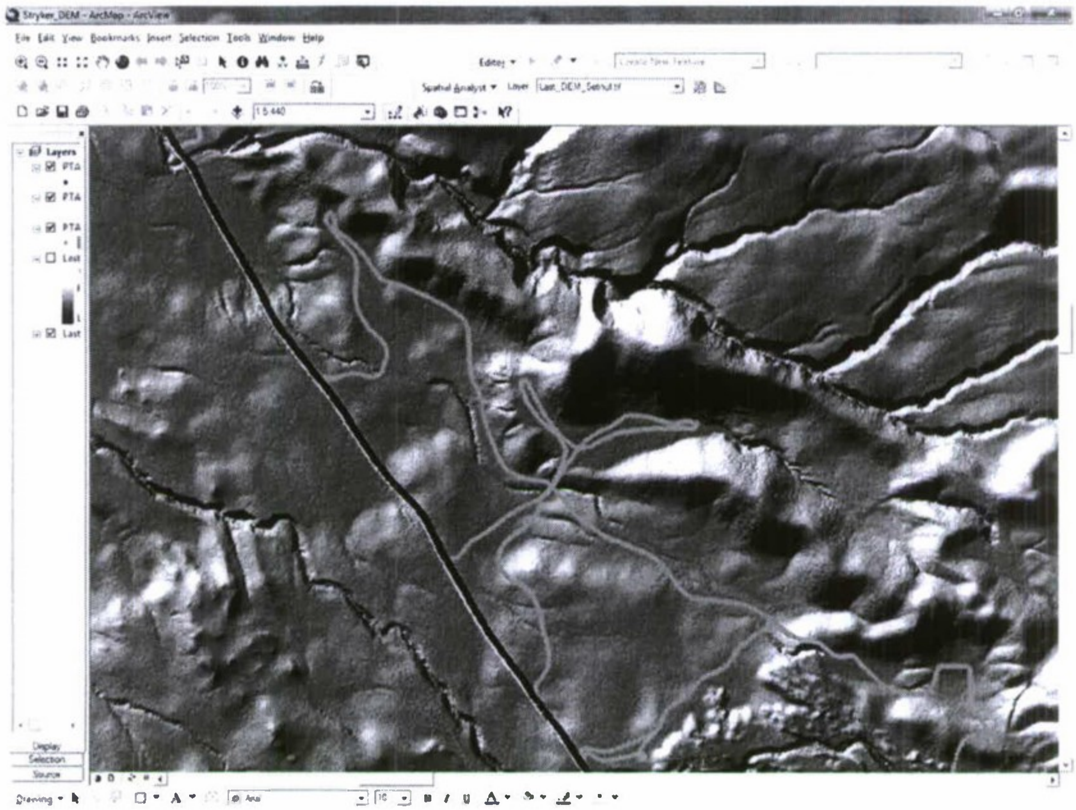

Figure 5. Off-road vehicle movement related to topography.

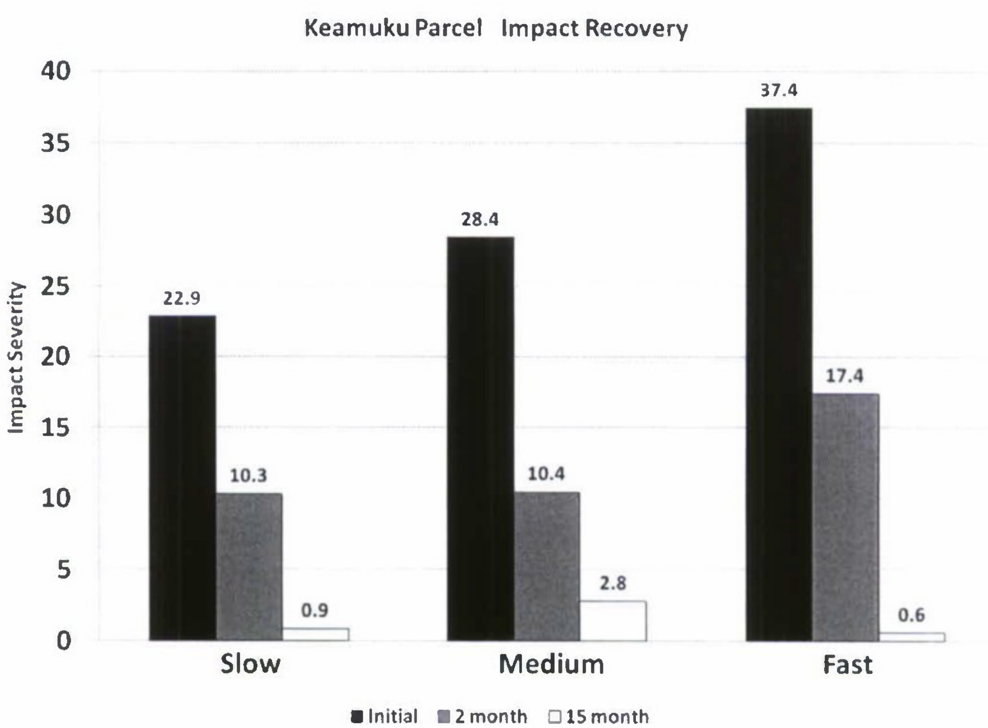

Figure 6. Vegetative recovery from the Stryker spirals conducted at PTA.